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(54) Title of the Invention: Device for Polishing the Mirror Surface of Wafers

(57) Abstract

Purpose: To polish to remove a target thickness from the surface accurately over an entire wafer regardless of pre-processing fluctuations in taper and thickness of the wafer.

Constitution: A pliable elastic film 13 is used on the surface that holds a wafer 16, with this elastic film 13 attached to a ring-shaped core 10 by a uniform tensile force, and a fluid supply means 20 for supplying a fluid for regulating the pressure holding the wafer 16 mentioned above is provided on the side opposite to the side holding the wafer 16 mentioned above.

[Claims]
1. A device for mirror surface polishing of wafers wherein mechanochemical polishing for polishing the flat surface of a wafer to a mirror surface through friction between the polishing plate and the wafer in which an alkaline polishing liquid with abrasive material dispersed in it is supplied to the level surface of a polishing plate and presses a wafer to the surface of this polishing plate, a thin, pliable film is used on the flat surface holding the wafer, and this film is attached to a ring-shaped core through a uniform tensile force, and a fluid supply means is provided on the surface opposite to the surface holding said wafer, and fluid is thereby provided to adjust the pressure on the wafer.
2. A device for polishing the mirror surface of wafers as claimed in Claim 1 wherein the space between the ring-shaped core to which the thin film is attached and the polishing plate is provided such that it is freely adjustable in altering the distance between near and far.
3. A device for polishing the mirror surface of wafers as claimed in Claim 1 wherein a ring is provided on the outside of the ring-shaped core and a thin film affixed to this ring, and there is provided a tensile force adjustment means for adjusting the tensile force on said thin film.

[Detailed Description of the Invention]
[0001]
[Field of Application in Industry] The present invention relates to a device for grinding and removing a target thickness accurately from the entire surface of a wafer regardless of pre-processing fluctuations in the taper and thickness of the wafer in a high-precision mirror surface polishing method for processing the surfaces of wafers, such as silicon wafers, for example, to undistorted mirror surfaces.
[0002] The fields of application for this device are the following two. (A) It is used when a prescribed thickness is desired by means of the polishing of a thin film on the surface of a wafer whereon a pattern has already been formed, as in a wafer using SOI (silicon on insulator), and a fixed film thickness can be maintained regardless of the surface roughness. (B) And it is used when wafers with a high degree of flatness without fluctuations can easily be obtained by flat surface polishing using diamond grinding stones. It is possible to polish them to a mirror surface without destroying this high degree of flatness.
[0003]
[Prior Art] With the increased integration of semiconductor devices, there are increasing requirements for high precision in the flatness of the wafers mentioned above, and ones with fluctuations of 1 μm or less in surface thickness are now required. However, conventional technology is such that in mechanochemical polishing for grinding the highly precise wafer flatness that is obtained through lapping or grinding with a diamond grinding stone in pre-processing to a mirror surface for the next stage, there is an extreme deterioration in the flatness, with tapering occurring in the wafer or a convex lens shape resulting.
[0004]
[Problems to be Solved by the Invention] This invention, among the various problems involved in mechanochemical polishing, changes and improves the thinking concerning the flat surface that holds the wafer. Detailed examples of the problems in the prior art for this part are as follows.
[0005] (A) With regard to methods for holding the wafer:
(i) when it is attached by wax, it is difficult to eliminate fluctuations in the thickness of the wax, and the occurrence of dimples because of the mixing in of fine particles cannot be avoided.

Furthermore, the flatness of the attaching carrier plate (the flat surface doing the holding) is duplicated in the finished flat surface of the wafer and as a result preserving this flatness is extremely complex.
[0006] (ii) A waxless method wherein the wafer is attached through a sponge-like back pad is used, but polishing agents, etc., are trapped in the holes in the sponge, the elasticity changes in places, and the flatness of the wafer deteriorates remarkably. Replacing the back pad after one or two uses to avoid this problem is economically disadvantageous. Furthermore, with this method, the periphery of the lens often forms a sagging convex lens shape, and improving this is extremely difficult.
[0007] (iii) Since methods that attach by vacuum impart the attachment surface shape (concentric circular grooves, for example) as is to the wafer surface, porous ceramics (porous materials) have been used recently. Further, hole sizes are becoming extremely small to avoid affecting the surface. As a result, there are problems such as the polishing agents clogging the holes, and measures (cleaning methods, etc.) to avoid this are difficult. Furthermore, as with (i), the flatness of the attachment surface is extremely important.
[0008] (B) With regard to mechanisms that support the holding surface and apply pressure:
(i) the method, as shown in FIG. 5 of polishing a wafer 3 by forcibly holding the holding surface 2 so that it remains parallel to the polishing plate 1 while pressure is supplied from the bottom is ideal if it can be done, but it is extremely difficult. More specifically, to achieve this, (a) the high rotary precision for both the polishing plate and the holding surface (the required precision exceeding precision parts, such as ball bearings, etc.), (b) maintenance of parallelism (with static pressure bearings, insufficient rigidity results when, for example, pressure is applied that leads to tilting), and (c) polishing speed are greatly affected by the application of pressure, and there are problems such as high rigidity, and the lack of an easily moving vertical slide axis, so there are no such devices in actual use.
[0009] Therefore, devices like the following are actually used.
(ii) Universal Type
Most actual equipment is made, as in FIG. 6, such that the holding surface 2 is made to rotate freely on a ball joint, and the holding plate 2 [*sic*] automatically follows the slant of the polishing plate 1, but the main disadvantage of this, as shown in the figure, is that when pressure P is applied for the sake of polishing, frictional force $\mu \times P$ arises, and torque $T = \mu \times P \times H$ arises such that the holding surface 2 slants according to the height H of the center of rotation. To make this torque T into 0, there is no alternative but to make H into 0. There have been concepts, such as those in FIG. 7 and FIG. 8, for improving this, but there are many issues that make for structurally impossible designs, and, at present, they do not perform as designed. Furthermore, as in FIG. 9, applied pressure P concentrates the load in the center, forming an equal distribution of load for polishing pressure p on the wafer, and the holding surface 2 is easily deformed; in order to hold the deformation to 1 μ or less, thickness must be increased and rigidity increased, which is contrary to the design for making the previously mentioned height H zero.
[0010] Therefore, the following floating type has been conceived to eliminate the deformation due to the application of pressure.
(iii) Floating Type
In the floating type, as in United States Patent 4,918,870, the applied force and the reactive forces of the wafer are both distributed loads because the holding surface is pressed by air pressure, so it is nearly ideal insofar as there is an even pressure on the entire surface without deformation of the holding surface, but it is insufficient because of the following points.

(a) Since a sponge-shaped back pad called an insert is used for holding the wafer, this defect remains unchanged.
(b) The holding surface is thick, and along with this affecting the flatness yielded from this surface, deformation accompanying differences in temperature cannot be avoided.
(c) The holding surface must follow the slanting and vertical vibration of the polishing plate with the O-ring part, but the frictional resistance of this part is large and it cannot follow with sensitivity.
(d) The O-ring part bears the frictional force in the horizontal direction generated by the applied pressure, but while bearing that force, the vertical tracking in (c) above cannot be done with sensitivity.
[0011] (C) Surface Polishing
With regard to surface polishing, an example of prior art for the basic surface polishing contained in the present invention is shown in FIG. 10. As in the figure, a rubber elastic body 4 that is 5 to 20 times [*sic*] the wafer 3 is sandwiched between the holding surface 2 and the wafer 3, and even if there is a large undulation in the surface of the wafer 3 or warping over the entire wafer 3, the wafer 3 is pressed substantially uniformly using this rubber elastic body 4, so that even if deformation arises in the wafer 3, the polished surface is in close contact with the polishing plate 1, making for uniform polishing. However, there are the following defects. (a) Since the rubber elastic body 4 applies as uniform a pressure as possible to the wafer 3, it must be made very thick, and it undergoes complex deformations because of the frictional force along the horizontal direction during polishing. (c) Since the mechanism for supporting and applying pressure to holding surface 2 is the conventional technology of a universal type, those defects are not eliminated, and sagging at the periphery, etc. cannot be avoided.
[0012] The present invention takes into consideration the above facts, so one object is to provide a device that has an ideal wafer holding surface, with the main object being to achieve theoretical equivalency without being affected by limits to structural precision and control over the entire mechanical device, regardless of the precision of the holding surface and with the pressure during wafer polishing in any position, and therefore, being able to remove by grinding a strictly fixed amount from the surface, that is, to carry out standard surface polishing.
[0013]
[Means to Solve the Problems] In order to achieve the objects mentioned above, Claim 1 of the present invention is one in which mechanochemical polishing for polishing the flat surface of a wafer to a mirror surface through friction between the polishing plate and the wafer in which an alkaline polishing liquid with abrasive material dispersed in it is supplied to the level surface of a polishing plate and presses a wafer to the surface of this polishing plate, a thin, pliable film is used on the flat surface holding the wafer, and this film is attached to a ring-shaped core through a uniform tensile force, and a fluid supply means is provided on the surface opposite to the surface holding said wafer, and fluid is thereby provided to adjust the pressure on the wafer.
[0014] Additionally, Claim 2 is one wherein the space between the ring-shaped core to which the thin film is attached and the polishing plate is provided such that it is freely adjustable in altering the distance between near and far.
[0015] Furthermore, Claim 3 is one wherein a ring is provided on the outside of the ring-shaped core and a thin film affixed to this ring, and there is provided a tensile force adjustment means for adjusting the tensile force on said thin film.

[0016]
[Operation of the Invention] With Claim 1 of the present invention, a fluid is supplied by a fluid supply means to the surface opposite the wafer-holding surface of the thin pliable film attached by a uniform tensile force to the ring-shaped core, and standard surface polishing is carried out smoothly by performing the polishing in a state wherein the pressure on the wafer is adjusted by the thin film mentioned above.
[0017] With Claim 2 of the present invention, the space between the thin film and the polishing plate is given an optimum value by adjusting the space between the ring-shaped core and polishing plate, bringing them closer or separating them, and sagging at the periphery of the wafer is eliminated.
[0018] With Claim 3 of the present invention, the ring makes a moving adjustment with the ring-shaped core and adjusts the tensile force on the film through a tensile force adjustment means.
[0019]
[Embodiments] An embodiment according to the present invention is described in the following based on FIG. 1 through FIG. 4.
[0020] In these drawings, 10 is a ring-shaped core, and a rigid-body plate 11 closes the surface of the upper edge of this ring-shaped core 10. A hollow shaft 12 is provided at the center of this rigid body plate 11, and this shaft 12 rotates freely and can be adjusted vertically. Furthermore, an elastic film (diaphragm) 13 that is as thin as possible is stretched across the surface of the lower edge of the above-noted ring-shaped core 10 by adhesion or another means. However, as is shown in FIG. 4, a ring 14 is mounted with freedom of vertical movement on the periphery of the ring-shaped core 10 with thin elastic film 13 attached to this ring 14 by adhesion or interposition, and this thin elastic film 13 may be stretched with a uniform tensile force by vertically adjusting the ring 14 with a screw 15. Furthermore, silicone rubber and other synthetic rubbers or woven fabric (cloth) reinforced rubber or a vinyl sheet, etc., is preferable for the material for the elastic film 13 mentioned above, and a thickness of 0.3–2.0 mm is preferable for the elastic film 13.
[0021] A plastic guide plate 17 with a hole slightly larger than the wafer 16 is attached to the bottom of the thin elastic film 13 mentioned above. Furthermore, in the closed space between the elastic film 13 mentioned above and the rigid body plate 11, the pressure required for polishing is applied by air or water by a fluid supply means 20. Furthermore, it is ideal for the shaft 12 mentioned above to be parallel to the center of rotation of the polishing plate 18, but even if it is slanted a little, etc., it can be absorbed by the elastic film 13 mentioned above. Furthermore, the effective diameter D for the pressure applied by the elastic film 13 for the wafer 16 diameter d is set large, and a proportion of $D/d = 1.05–1.20$ is preferable. And further, there is provided a vertical adjustment mechanism (not shown in the drawing) on the shaft 12 mentioned above such that the distance H between the surface of the polishing plate 18 and the surface of the elastic film 13 is computed accurately and there is no change during polishing. Machine tools, such as mechanisms that maintain prescribed distances for material being ground by polishing stones during grinding with flat grinding plates, may be appropriated for use as this vertical adjustment mechanism.
[0022] When the polishing device configured as in the above is used for mirror finishing of the surface of a silicon wafer 16, the wafer 16 is first attached inside the guide plate 17 by flooding with water. Next, the entirety is lowered gently, and affixed at the distance prescribed by dimension H. Here, the prescribed dimension is found by experiment, but it is determined by the modulus of elasticity of the elastic film 13, the tensile force, and the D/d ratio. As is shown in FIG. 2, if H is large, it means that the elastic film 13 is raised at the periphery of the wafer 16,

and the polishing pressure drops. Conversely, if H is small, the elastic film 13 is pushed up as in FIG. 3, and a large pressure is applied to the periphery. Therefore, the ideal position is found and set between these. Next, polishing begins by applying air pressure through a precision pressure gauge to the back surface of the elastic film 13. Furthermore, after polishing for a prescribed time, the air pressure is released, and subsequently the entirety is raised and the wafer 16 removed.

[0023] The wafer 16 is in the manner noted above polished smoothly, and the important point in the present invention is, first of all, the uniform stretching and attachment of the thin elastic film (diaphragm) 13 with a fixed tensile force. Various methods are possible for this, but the most typical is gently tapping the elastic film 13 as it is stretched and checking the vibration (acoustic) of the film like as if it were a drum. Next is determining dimension H in the drawings experimentally and accurately repeating that dimension. Here it is necessary to rotate the polishing plate 18 as precisely as possible, but a vertical fluctuation of approximately 5–10 μm cannot be avoided. Furthermore, the surface stretching the elastic film 13 has the same type of surface fluctuations, and as a result dimension H varies along with the rotation, and it is necessary to hold that value to approximately 5–20 μm. In this case, the diaphragm is an elastic film, so it can absorb small fluctuations in dimension H mentioned above; therefore, the absorption is determined by the D/d ratio. Furthermore, it may be thought that the larger D/d is the better from the standpoint of absorption, but on the other hand, from the relationship of the strength of this diaphragm with respect to pressure, a small value for D/d is better, so, naturally, there is a limit to the size.

[0024]

[Effects of the invention] As described above, there are the following effects of the present invention.

1. Since pressure is applied to the wafer directly by air through a thin film, pressure can be applied uniformly to every position.
2. There is no rigid absorption plate or carrier plate. There is also no need to control their flatness or temperature.
3. Since it is a thin film, the heat capacity is small, and since it is by means of air, there are high insulating properties. Therefore, it is easy for the wafer temperature to be uniform in all places.
4. In typical polishing, there is often sagging at the periphery, but by providing freedom of adjustment for increasing or decreasing the distance between the ring-shaped core to which the thin film is attached as previously described and the polishing plate, this can be prevented.
5. Since complete standard surface polishing can be performed, the utility value of the above in industry is high.
6. Even if there is a certain amount of vibration or error in the mechanical device as a whole, it is absorbed by the thin film, and it does not affect the flatness (quality) of the wafer.
7. The thin film tensile force can be adjusted to the optimum value by providing a tensile force adjusting means on a ring provided on the periphery of the ring-shaped core.

[Brief Description of the Drawings]

FIG. 1 is a cross-sectional drawing showing an embodiment according to the present invention.
FIG. 2 is an explanatory drawing showing the case in which distance H is excessively large.
FIG. 3 is an explanatory drawing showing the case in which distance H is excessively small.
FIG. 4 is an explanatory drawing showing an example of a tensile force adjusting means for the elastic film.

FIG. 5 is a cross-sectional drawing showing a first example of a conventional polishing device.
FIG. 6 is an explanatory drawing showing a second example of a conventional polishing device.
FIG. 7 is a cross-sectional drawing showing a third example of a conventional polishing device.
FIG. 8 is a cross-sectional drawing showing a fourth example of a conventional polishing device.
FIG. 9 is an explanatory drawing showing a fifth example of a conventional polishing device.
FIG. 10 is an explanatory drawing showing a sixth example of a conventional polishing device.

[Explanation of the Reference Numbers]

10	Ring shaped core
13	Elastic film (diaphragm)
14	Ring
15	Screw (tensile force adjustment means)
16	Wafer
18	Polishing plate
20	Fluid supply means

FIG. 1

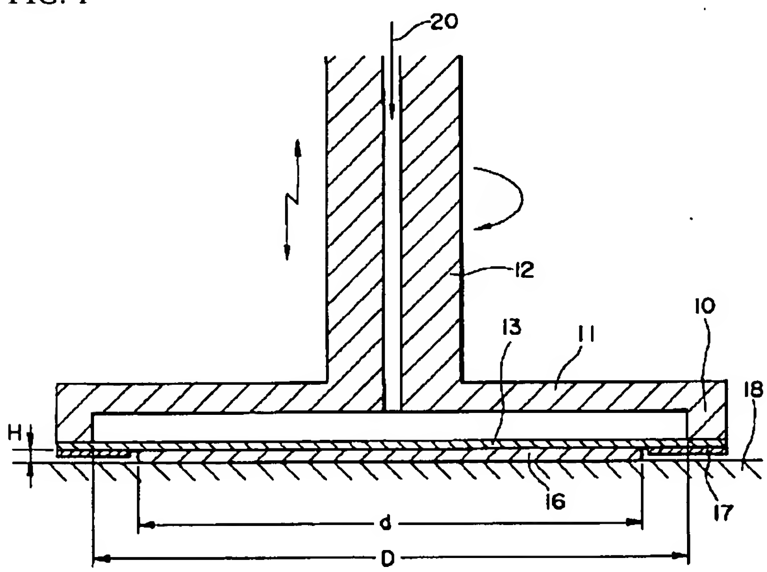

FIG. 2

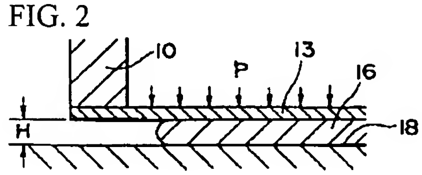

FIG. 3

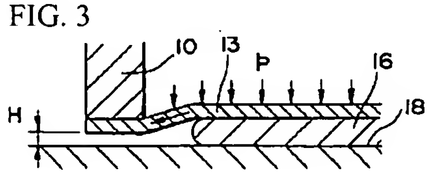

FIG. 4

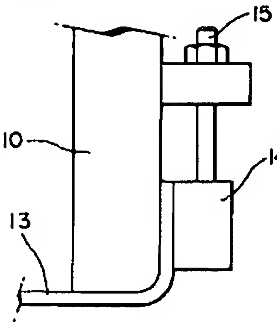

FIG. 5

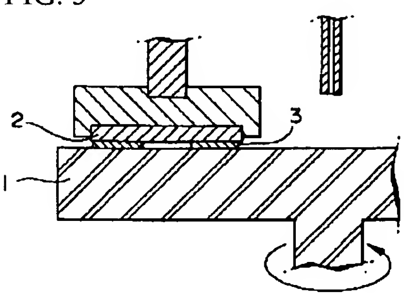

FIG. 6

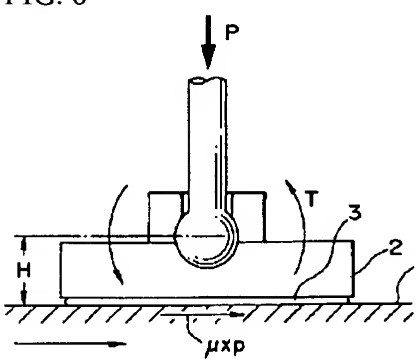

FIG. 7

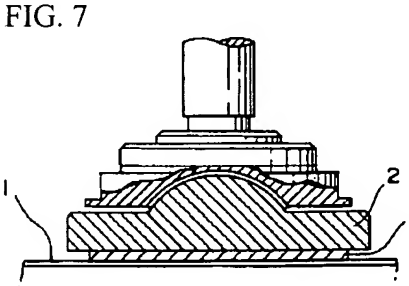

FIG. 8

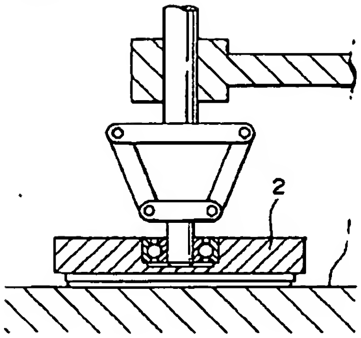

FIG. 9

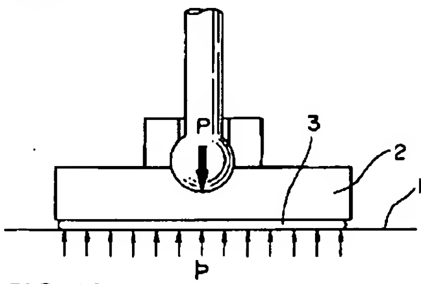

FIG. 10